

## Making Core Memory: An Experiment in Troubling Computing Histories

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In a two-minute clip from the docuseries *Moon Machines*, two women in white smocks pass a needle back and forth through a matrix of eyelet openings.<sup>1</sup> Sitting under task lamps in a Raytheon facility outside of Boston, they are making “core memory” for the Apollo Guidance Computer. They thread the wire through the ferrite cores and code one bit of information into each connection. It looks similar to weaving.<sup>2</sup>

But does core memory manufacturing just *look* like weaving to us, as researchers? Or was it thought of as weaving by the people who were involved in the process? In interviews we conducted with core memory engineers from early computing firms, weaving comprised a novel and unfamiliar way of conceptualizing the wiring of magnetic cores. To describe this process, the engineers often used the generic term

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<sup>1</sup> *Moon Machines*, docuseries, 2008.

<sup>2</sup> [www.makingcorememory.org](http://www.makingcorememory.org).

“assembly” in their reflections, a term typically deployed to characterize the manufacturing of computer components more broadly.<sup>3</sup> “Until this discussion I had never heard of ‘stringing cores’ as a weaving problem,” explained Frederick Dill, pioneering engineer and co-inventor of the semiconductor laser. In later communication with us, he elaborated: “Your focus on ‘weaving’ is an equally valid viewpoint, but a different one. It sort of assumes that some particular configuration of weaving will produce what is needed . . . which is totally correct.”<sup>4</sup>

Despite Dill’s apparent unfamiliarity with weaving, textile metaphors pervaded descriptions of the Apollo core memory manufacturing process to the public during the 1960s. When Raytheon manager Ralph Ragan explained the challenge of building the Apollo Guidance Computer (AGC) to the press, he made this link explicit. “We have to build, essentially, a weaving machine,” he asserted.<sup>5</sup> Press kit photos described core memory being made by “space age needleworkers” who were “threading” wires.<sup>6</sup> In an introductory video made by MIT, the reporter describes the program code as being captured in “the pattern of the sewing.”<sup>7</sup> Internally, Raytheon’s report on the AGC programs also referred to their “weaving” and testing.<sup>8</sup>

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<sup>3</sup> Dick Weaver, interview by Daniela K. Rosner, 8 March 2017.

<sup>4</sup> Frederick Dill, interview by Daniela K. Rosner, 18 March 2017.

<sup>5</sup> David A. Mindell, *Digital Apollo: Human and Machine in Spaceflight*, Inside Technology (Cambridge, MA: MIT Press, 2008).

<sup>6</sup> David Meerman Scott and Richard Jurek, *Marketing the Moon: The Selling of the Apollo Lunar Program* (Cambridge, MA: MIT Press, 2014).

<sup>7</sup> “MIT Science Reporter—‘Computer for Apollo’ (1965),” YouTube video, 29:20, from the 1965 television program *MIT Science Reporter*, posted by “From the Vault of MIT,” 20 January 2016, [www.youtube.com/watch?v=ndvmFlg1WmE](http://www.youtube.com/watch?v=ndvmFlg1WmE).

<sup>8</sup> Raytheon Company Equipment Division, “Apollo Guidance Computer Program Block 1 (100) and Block II,” 31 December 1969, Apollo Lunar Equipment Collection, Smithsonian National Air and Space Museum.

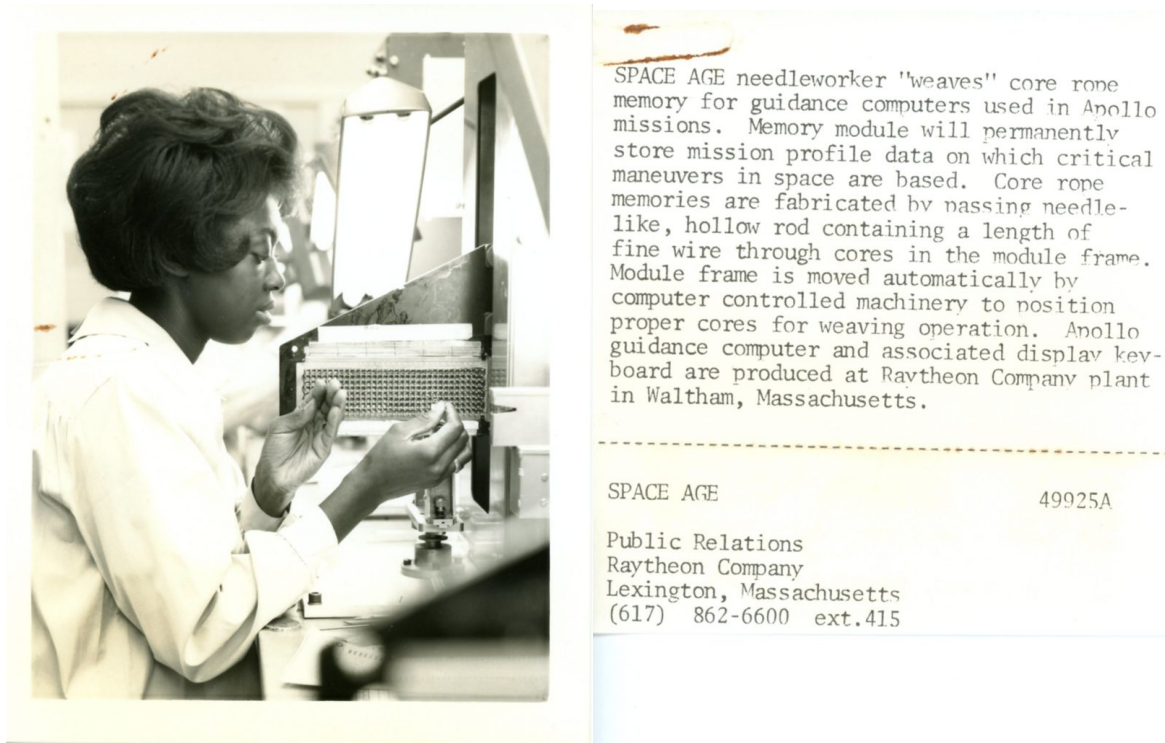


Figure 1. An unknown woman weaves core memory in a photograph from a Raytheon Apollo 11 Press Kit. (Right) Photo caption describing the woman as a “space age needleworker.” (Source: Raytheon photos courtesy of the collection of David Meerman Scott, author of *Marketing the Moon: The Selling of the Apollo Lunar Program* [Cambridge: MIT Press, 2014].)

The language of weaving and textiles have an explanatory power. They draw our attention to contributions that exceed the material capacities of electronic components. As opposed to more neutral terms like “operation” and “assembly,” weaving connects us to lineages of women’s work thousands of years old.<sup>9</sup> It challenges the widespread omission of embodied practice—or bodies at all—within core memory literatures. It locates women, many of whom are women of color, as central contributors to computing.

These connections between weaving and wiring, textiles and computing, inspired Making Core Memory, an exploratory technology history project we’ve made available for you at [makingcorememory.org](http://makingcorememory.org). With Making Core Memory, we use weaving and textiles as not only metaphors but also a means of historicizing computing. We

<sup>9</sup> E. J. W. Barber, *Women’s Work: The First 20,000 Years: Women, Cloth, and Society in Early Times*, 1st ed. (New York: Norton, 1994).

invite *Technology's Stories* readers to revisit the story of the core memory weavers as a way to explore under-recognized contributions to early computer innovation.

The software programs for the Apollo moon missions were permanently stored through hard wiring the code into “core rope memories.” Each core rope comprised wires of two types: address wires and sense wires.<sup>10</sup> The sense wire was especially important. It was woven through the cores in a pattern, physically encoding the 1s and 0s of binary code. When the wire passed through a ferrite core, it would be read as 1. When it passed around the core (missing it completely), it would be read as a 0.<sup>11</sup> The weavers had the help of a machine that would let them know which cores needed threading.<sup>12</sup> By inviting you to weave core ropes yourself, we hope that you ask new questions of your practice.

In order to rework who builds our worlds today, we need to rework how we tell stories about our pasts. In Saidiya Hartman’s words, “Inheritances are chosen as much as they are passed on. The past depends less on ‘what happened then’ than on the desires and discontents of the present. *Strivings and failures shape the stories we tell*—and, we might add, *the futures we create*.”<sup>13</sup>

[www.makingcorememory.org](http://www.makingcorememory.org)

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<sup>10</sup> Raytheon Company Equipment Division, “Apollo Guidance Computer Program Block 1 (100) and Block II.”

<sup>11</sup> Paul Ceruzzi, “The ‘Rope Mother’ Margaret Hamilton,” *Smithsonian National Air and Space Museum*, 11 March 2016, <https://airandspace.si.edu/stories/editorial/rope-mother-margaret-hamilton>.

<sup>12</sup> Lee Woodworth, interview by Samantha Shorey, 5 March 2019.

<sup>13</sup> Saidiya V. Hartman, *Lose Your Mother: A Journey along the Atlantic Slave Route*, 1st ed. (New York: Farrar, Straus and Giroux, 2007).